

PATENT SPECIFICATION

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(54) VEHICLE SUSPENSION SYSTEMS

(71) I, MAURICE PETER PHILLIPPE, a British Subject, of 13, St. David's Road, Hetherett, Norfolk, do hereby declare the invention for which I pray that a patent 5 may be granted to me and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to vehicle suspensions 10 and seeks to improve the geometric control of the wheels during a turn and thereby significantly to extend the stability and safety of the vehicle when cornering, particularly at high speeds.

15 In the field of automotive vehicles there are certain inherent stability problems that result from the inability of the fixed geometry employed in the suspension linkage to maintain the wheels in the ideal plane relative to the road or operating surface during the execution of a turn. Development of vehicle suspension has resulted hitherto in the adaption of independent wheel suspensions rather than the solid axle

20 type to minimise interaction between a pair of wheels on a common axle, and to reduce unsprung weight, but this results in acceptance of adverse wheel plane or camber effects in a turn. The action of cornering produces centrifugal forces which result in the sprung parts of the vehicle rolling around an axis determined by the particular geometry used. The roll mechanics involved are well-known and established. The angle 25

30 of roll through which the body or chassis passes is determined by the stiffness of the springing employed. The roll in the chassis in turn causes the inner ends of the suspension linkages to move through the same angle and consequently the wheel planes are changed. The widely employed methods of 35 independent suspension are the double parallel link or the so-called "Macpherson strut" and these usually have unequal length links 40 or geometry arranged to reduce the camber

change in cornering. This results in only a small improvement however, and the wheels adopt almost the same angular change in cornering as the chassis. The direction of the camber change is always away from the 50 instantaneous centre of turn of the vehicle and this is termed as positive camber. It has been established by various research organisations, including Cornell University, 55 that a pneumatic rubber tyred wheel produces its maximum cornering force when the plane of the wheel is at or near perpendicular to the road surface. As the plane of the wheel moves away from the vertical the cornering force capability is reduced.

60 There have been many attempts to overcome these deficiencies, but these in the main have utilised modifications to the suspension linkage without utilising an energy source, and accordingly suffer from the normal laws of mechanics in the balancing of forces, and do not therefore provide a satisfactory solution.

65 According to the invention there is provided a vehicle independent wheel suspension 70 system including a pressure medium operated camber control servo-unit having a valve means operated by means responsive to the direction and magnitude of lateral forces applied to the vehicle and generating 75 chassis roll, said servo-unit applying a correction to the suspension whereby the suspension geometry is varied to maintain the position of the wheel planes substantially 80 perpendicular to the running surface.

85 This invention accepts the necessity of an energy source to eliminate camber change in cornering. All motor vehicles have a prime mover or energy source to drive them and the preferred system for suspension geometry control, described herein, utilises a minute amount of prime mover energy in the form of fluid or air under pressure. In this form the device can be applied to any 90 land based vehicles, for example, by adding

a small pressure pump or compressor to the vehicle prime mover or driving engine.

A preferred embodiment of the present invention will now be described by way of example and with reference to the accompanying drawings, in which:

Figure 1 illustrates a suspension incorporating a servo system to control wheel geometry according to the techniques of the 10 present invention.

Figure 2 is a section drawing of the servo unit itself and shows schematically the arrangement of the sensing pendulum, the porting and the valving.

Figure 3 is a detail section to illustrate the fail-safe lock mechanism of the servo unit, and

Figure 4 illustrates the application of the invention to the most widely used types of 20 suspension.

Referring now to Figures 1, 2 and 3, there is shown the preferred embodiment for the geometry control device.

Figure 1 shows a suspension of the double 25 parallel link type under the action of dynamic cornering. Shown in broken-chain dotted lines are the vehicle centreline 23, chassis 31 and wheels 20, as they would be when the vehicle is travelling in a straight 30 line. The roll axis 49 for the suspension shown is at ground level. Under centrifugal forces occasioned by cornering the balancing centripetal forces cause the suspension springs 59 to deflect, allowing the chassis to 35 roll through the angle 11 and the chassis centreline to lie now along axis 24. Without the servo unit 26 in action the wheels 20 are controlled by the upper links 17, lower links 18 and uprights 29 to change camber 40 through angle 10 and the wheels now have planes 16. The track 15 of the wheels 20 remains the same, but the action of cornering has caused the wheels to assume positive camber as shown by the chain dotted-line 45 19. This angular relationship to the road surface 33 would greatly impair the potential wheel side "bite" or cornering force. The servo unit 26 has a pendulum sensing device 28, however, which under cornering 50 forces assumes position 27. The weight of the pendulum 48 remains constant, but the centrifugal force 47 causes the pendulum to assume an angular displacement which is towards the outside of the turn and of a 55 magnitude that is in proportion to the cornering force. The pendulum therefore senses the direction of turn and the lateral acceleration or rate of turn. The pendulum 28, through valve arrangements, to be described later, causes energy source fluid or air under pressure to bear on a piston, such that piston rod 25 is moved by a prescribed amount. Piston rod 25 is arranged in the 60 preferred arrangement to have the upper links 17 of the suspension attached to its 65 outer ends. Displacement of the piston therefore changes the lateral position of the in-board pivots 12, 13 for the top links 17 and this corrects the angular relationship of the wheels 32 to the road surface 33, the wheel 70 centrelines are now at the position 21 and the track 14, whilst being the same amount as in straight line running 15 is now displaced a little towards the outside of the turn. The wheels 32 are therefore always 75 maintained with the wheel plane effectively vertical to the road surface 33 at all times by servo unit 26 and its pendulum control.

Referring now to Figure 2, the servo unit 26 is shown with piston and valves in the mid-position or as they would be with the vehicle travelling in a straight line. The pendulum control valve 46 has four cross drillings arranged along its length to coincide with similar cross drillings in an outer sleeve valve 45, and inlet and outlet ports 35, 36, 37 and 38 in servo body 26. The piston 34 has a piston rod 25 with a lever 39 clamped to it. The lever 39 is connected by link 40 to a lever on outer sleeve valve 90 45, such that angular movement of valve 45 is related to piston 34 displacement. As described earlier, and as shown in Figure 2, centrifugal forces act on the pendulum weight and displace it laterally to a position 95 such as shown at 27. This rotates valves 46 in an anti-clockwise direction and brings the drillings on the extreme left and third from left to a position in which they will allow the passage of the pressure energy 100 medium. Port 36 is now connected to the pressure source fed into the servo unit at 43 and port 38 is open to exit connection 42. The anti-clockwise rotation of valve 46 meanwhile causes the second and fourth 105 drillings from the left to be further away from an open position and therefore cannot have any control of the piston at this stage. A pressure differential is now present across piston 34 and it moves accordingly to the 110 left. The piston rod moves to position 41 and via link 40 rotates the outer sleeve valve in an anticlockwise direction. This results in the closing off of the previously open ports 36 and 38 and further movement 115 of the piston then ceases as no pressure differential now exists across it. The piston 34 moves a distance which is proportional to the displacement of the pendulum, which is in itself displaced proportionally according 120 to the rate of cornering.

On resuming a straight path the pendulum is acted on by gravity alone and resumes a vertical position as shown at 28. This is a clockwise rotation of valve 46 relative to outer sleeve valve 45, which is still in its angular position as dictated by lever 39 in its displaced position 41 through link 40. Ports 37 and 35 now communicate with pressure inlet 43 and exit connection 44. A 130

reverse pressure differential now exists across piston 34 and it moves to the right until outer sleeve valve 45 has regained its original position and all ports are closed.

5 The sensing and valve system therefore reacts to the direction and magnitude of the cornering forces and controls the movement of piston rod 25 commensurate with the required change in suspension geometry to

10 maintain the vehicle wheel planes vertical.

When the vehicle is parked or not in use there is no primary power available to maintain sufficient pressure for the servo system. As shown in Figure 3 an automatic lock is incorporated in one end of the servo unit 26. Piston rod 25 is provided with a semi-circular groove 54 which matches a group of steel balls 53. The steel balls are surrounded by an annular shroud which is integral with secondary piston 50. When the piston rod 25 is in its mid-position the groove is located in such a position that steel balls 53 are prevented from escaping radially from the groove by the annular shroud 20 on piston 50. Piston 50 is held to the left-hand end of the secondary cylinder by a helical spring 51 and therefore mechanically prevents movement of piston rod 25. The secondary cylinder has a port 52 connected 30 to the servo unit pressure supply line. When sufficient pressure is available to operate the servo unit the pressure is also applied to piston 50 and this overcomes the retaining spring 51. The displacement of the annular shroud now allows the steel balls to expand radially out of the lock groove and piston rod 25 is free to move in either direction. This lock also comes into effect 35 in the event of pressure loss when the vehicle 40 is in motion and therefore provides a fail safe lock, allowing the vehicle to remain in use, all be it without the advantage of geometric suspension control.

The invention is applicable to all types of 45 wheeled land based vehicles employing independent suspensions. The mostly widely adapted types of suspension are depicted in Figure 4 and 55 depicts a parallel link system and the preferred application of the 50 servo unit. The top link is the most apt location for the servo unit in that the required operating loads are lower in the upper links as opposed to the lower links and pressure levels or servo piston area can 55 be kept at a minimum. The system may be employed at the front of a vehicle where independent suspension is only employed at that end or at both ends where independent suspension is employed front and rear. When 60 the servo is applied in the front suspension as shown in 55 it is preferable to keep the steering arm and linkage ideally at the level of the lower suspension link to minimise steering errors when camber correction takes 65 place. Generally, the average vehicle does

not have very accurate steering geometry so that this need not preclude the use of the system on an existing vehicle, where steering geometry is established. The arrangement 57 shows the servo unit incorporated in a Macpherson strut suspension by interconnecting the top ends of the struts. The servo unit need not be positioned on vehicle centreline as shown to be effective. In the suspension arrangements 56 and 58 70 there are servo units incorporated in two of the suspension links, but they are linked to a chassis mounted valve and sensing system by flexible pressure lines. This might be a more convenient application where space is limited and the preferred arrangement is not possible. The location of the sensing and valve unit can be anywhere on the vehicle providing the sensing pendulum swings in a lateral plane relative to the vehicle centreline, and a link is provided to index the outer sleeve valve relative to the servo piston units. There are numerous ways in which the device may be incorporated and these examples show only some of them. 75

The present invention accurately senses the cornering forces in a vehicle and automatically corrects any camber deficiencies caused by the forces present in cornering. This greatly improves the ultimate cornering forces attainable in the vehicle and therefore increases stability and safety of the vehicle. A further modification to the pendulum is that of placing it in an enclosed chamber so that it is immersed in fluid or gas (air). This provides viscous damping to the pendulum and limits hysteresis movements caused by valve hammer characteristics, or movement of the pendulum caused by vertical accelerations of the vehicle when traversing road surface deformations. Another advantage is that tyre wear is improved as the whole width of the tyre tread or footprint is always presented to the road surface, whereas the tyre shoulders with conventional independent suspensions wear unevenly. The invention describes the preferred method for sensing cornering forces and energy source, but the control could be effected by sensing from the steering unit or by suspension link disposition and the servo could be operated electrically as well as by fluids or gas. 100

The described invention provides a vehicle suspension arrangement including a servo 110 system which opposes the tendency for the wheels of the vehicle to adopt adverse planes relative to the surface on which the vehicle is operating during the execution of a turn. The servo unit acts on the linkage employed 115 in the suspension to maintain the wheel plane substantially at right-angles to the operating surface under all deviations that the vehicle may make from travelling in a straight line. The servo unit has a pen- 120 125 130

- dulum control system which senses the direction and magnitude of the deviation from straight line running of the vehicle and applies the appropriate change to the geometry. The system incorporates a fail safe isolation lock in the event of interruption of the power source to the servo unit, allowing the vehicle to continue operation, but without the advantages of geometry control.
- 5 10 The fail safe lock also performs the function of locking the suspension in the neutral position when the vehicle is parked or not in use.
- WHAT I CLAIM IS:-
- 15 1. A vehicle independent wheel suspension system including a pressure medium operated camber control servo-unit having a valve means operated by means responsive to the direction and magnitude of lateral forces applied to the vehicle and generating chassis roll, said servo-unit applying a correction to the suspension whereby the suspension geometry is varied to maintain the position of the wheel planes substantially 20 25 perpendicular to the running surface.
2. A suspension system according to claim 1 wherein the means responsive to lateral forces is a pendulum.
3. A suspension system according to claim 1 or claim 2, wherein the servo-unit is provided with viscous damping means for the means responsive to lateral forces.
4. A suspension system according to any one of claims 1 to 3, wherein the servo unit is provided with means to lock the system in the neutral position when the pressure in the system is below a predetermined level.
5. A suspension system according to claim 1 wherein the means responsive to lateral forces are connected to a vehicle wheel steering means.
6. A suspension system according to claim 1 wherein the means responsive to lateral forces are directly connected to the wheel suspension members.
7. A vehicle independent wheel suspension system substantially as hereinbefore described with reference to the accompanying drawings.

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Sheet 1

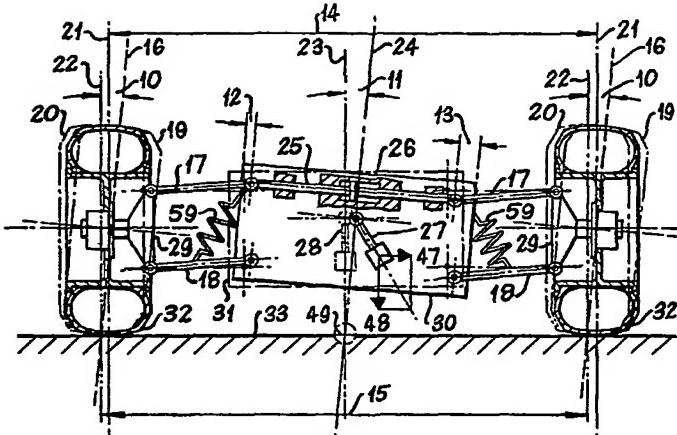


Fig. 1

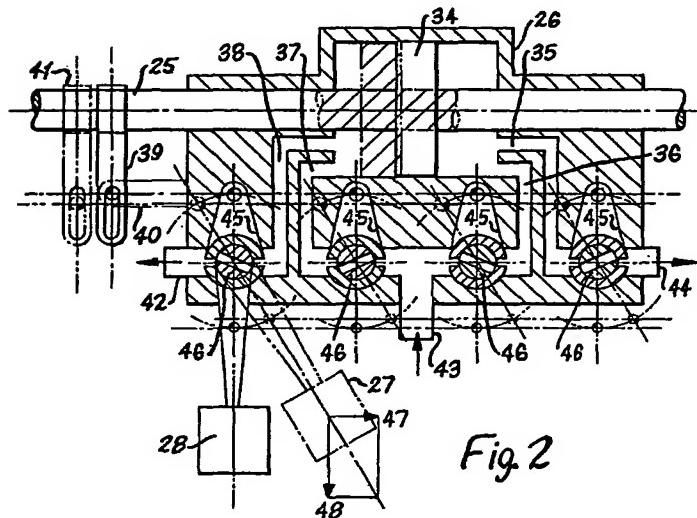


Fig. 2

1526970 COMPLETE SPECIFICATION
2 SHEETS *This drawing is a reproduction of
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Sheet 2

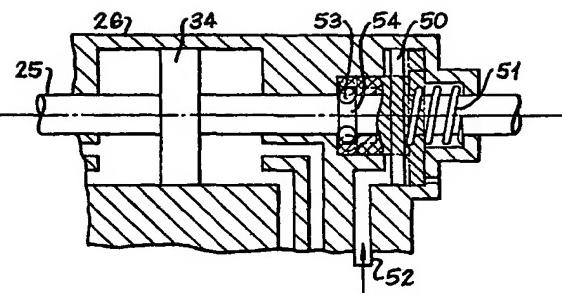


Fig. 3

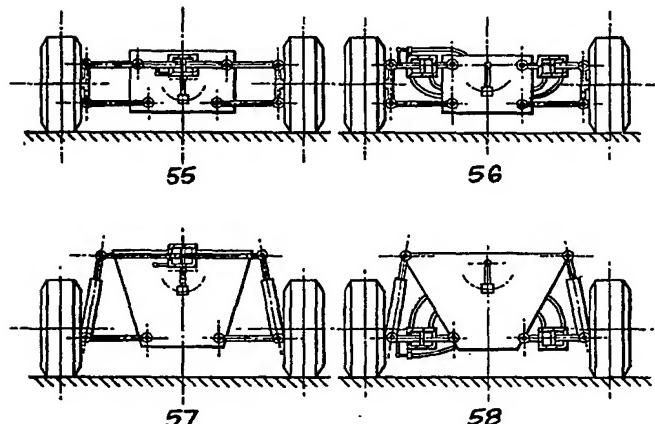


Fig. 4